**Signals & Systems**

**EEE-223**

Lab # 11



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**LAB # 11**

**Continuous Time Fourier Transform (CTFT)**

**Lab 11-** **Continuous Time Fourier Transform (CTFT)**

**Pre Lab**

Fourier transform is used to transform a time domain signal into frequency domain. As some times frequency domain reveals more information as compared to time domain. In this lab, the Fourier transform for continuous-time signals will be discussed which is known as continuous-time Fourier transform (CTFT). By applying, Fourier transform to a continuous time signal *x* (*t* ) , we obtain a representation of the signal at the cyclic frequency domain  or equivalently at the frequency domain *f* .

The Fourier transform is denoted by the symbol *F*{.} ; that is, one can write (11.1) as

*X* () *F* {*x* (*t* )} (11.1)

In other words, the Fourier transform of a signal *x*(*t*) is a signal *X*() . An alternative way of writing eq. (11.1) is given in eq. (11.2) and eq. (11.3) shows mathematical from of Fourier transform.

*x* (*t* )*F* *X* () (11.2)

From eq. (11.3) it is clear that is complex function of Ω. Where Ω =2лf substituting in eq. (11.3) we get

In order to return from the frequency domain back to the time domain the *inverse* Fourier transform is implemented. The inverse Fourier transform is denoted by the symbol; i.e. *F* -1{.}

*x* (*t* ) *F* 1{ *X* ()} (11.5)

or alternatively,

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*X* ()*F* *x* (*t* ) (11.6)

Mathematically, inverse Fourier transform is given by

or

The cyclic frequency  is measured in rad/s, while the frequency *f* is measured in Hertz. The Fourier transform of a signal is called (frequency) *spectrum.* MATALB command for Fourier transform is “fourier” and for inverse Fourier transform it is “ifourier”.

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# In-Lab Tasks

#### Task-1

Compute the Fourier transform of . MATLAB code is given in following, run this code and compare your output using eq. (11.3). Write your code and results in following.

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| syms w t  x = exp(-t.^2);  X=foprier(x,w);  **OUTPUT**  X =  pi^(1/2)\*exp(-w^2/4) |

#### Task-2

Compute the inverse Fourier transform of X = exp(-1/4\*w^2)\*pi^(1/2) using the command for inverse Fourier transform and also verify your result using eq. (11.7). Give your results in following.

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| syms t w  X = exp(-1/4\*w^2)\*pi^(1/2);  ifoprier(X,w)  **OUTPUT**  ans =  (3991211251234741\*exp(-w^2))/(2251799813685248\*pi^(1/2)) |

#### Task-3

Compute the inverse Fourier transform of the function *X* () 1**/** (1  *j*) using command of Fourier and then take inverse of the resultant x(t) to produce again *X* ().

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| Part 1)  syms t w  x = 1/1+(1i\*w))  foprier(x,t)  **OUTPUT**  x =  1/(1 + w\*-i)  ans =  -pi\*exp(t)\*(sign(t) - 1)  Part 2)  syms f  w = 2\*pi\*f  syms t  x = -pi\*exp(t)\*(sign(t) - 1)  ifoprier(x,w)  **OUTPUT**  w =  2\*pi\*f  x =  -pi\*exp(t)\*(sign(t) - 1)  ans =  1/(pi\*f\*2i + 1) |

#### Task-4

Let x(t) = 1, compute its Fourier transform to produce X(w) and then take inverse Fourier transform of X(w) to get back x(t), using commands of Fourier transform.

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| Part 1)  syms t w  x=1  X=foprier(x,w)  **OUTPUT**  x =  1  X =  2\*pi\*dirac(w)  Part 2)  syms t w  x=2\*pi\*dirac(w)  x=ifoprier(x,t)  **OUTPUT**  x =  2\*pi\*dirac(w)  x =  1 |

#### Task-5

Let x(t) = u(t), compute its Fourier transform, take inverse Fourier transform of the resultant signal to get back x(t).

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| Part 1)  t=0:1:5  syms w  x=t>=0  X=foprier(x,w)  **OUTPUT**  t =  0 1 2 3 4 5  x =  1×6 logical array  1 1 1 1 1 1  X =  [ 2\*pi\*dirac(w), 2\*pi\*dirac(w), 2\*pi\*dirac(w), 2\*pi\*dirac(w),  2\*pi\*dirac(w), 2\*pi\*dirac(w)]  Part 2)  syms t w  x=[ 2\*pi\*dirac(w), 2\*pi\*dirac(w), 2\*pi\*dirac(w), 2\*pi\*dirac(w),  2\*pi\*dirac(w), 2\*pi\*dirac(w)]  x=ifoprier(x,t)  **OUTPUT**  x =  [ 2\*pi\*dirac(w), 2\*pi\*dirac(w), 2\*pi\*dirac(w), 2\*pi\*dirac(w),  2\*pi\*dirac(w), 2\*pi\*dirac(w)]  x =  [ 1, 1, 1, 1, 1, 1] |

#### Task-6

Let x(t) = , compute its Fourier transform, take inverse Fourier transform of the resultant signal and state whether it is possible to get back x(t) or not?

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| Part 1)  syms t  x=dirac(t)  X=foprier(x,w)  **OUTPUT**  x =  dirac(t)  X =  1  Part 2)  syms t  x=1  X=ifoprier(x,t)  **OUTPUT**  x =  1  X =  dirac(t)  **Hence it is possible to get x(t) back** |

#### Task-7

Prove that and X are Fourier transform pairs of each other.

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| Part 1)  syms t  x=dirac(t-2)  X=foprier(x,w)  **OUTPUT**  x =  dirac(t - 2)  X =  exp(-w\*2i)  Part 2)  syms t w  x=exp(-w\*2i)  X=ifoprier(x,t)  **OUTPUT**  x =  exp(-w\*2i)  X =  dirac(t - 2)  **Hence** x(t) **and X(**Ω) **are Fourier transform pairs of each other.** |

#### Task-8

Prove that and X are Fourier transform pairs of each other.

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| Part 1)  syms w t x  a = heaviside(x-2);  A=foprier(a,w)  **OUTPUT**  A =  exp(-w\*2i)\*(pi\*dirac(w) - 1i/w)  Part 2)  syms w t x  A=exp(-2\*j\*w)\*(pi\*dirac(w)-j/w);  a=ifoprier(A,w)  **OUTPUT**  a =  (pi + pi\*sign(w - 2))/(2\*pi)  **Hence** x(t) **and X**(Ω) **are Fourier transform pairs of each other.**   |  | | --- | | **Critical Analysis / Conclusion** In this lab we learnt how to transform a continuous time domain signal into continuous frequency domain using the concept of Fourier Transform. we also learned how to take inverse Fourier Transform using MATLAB. | |

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| **Lab Assessment** | | |
| **Pre-Lab** | **/1** | **/10** |
| **In-Lab** | **/5** |
| **Critical Analysis** | **/4** |
| **Instructor Signature and Comments** | | |